Telecommunications for Television/Advanced Television: Forecasts of Markets and Technologies

New Telecommunications Services and the Public Telephone Network

1993 Personal Communications: Perspectives, Forecasts, and Impacts

1994 Transforming the Local Telephone Network: Analyses and Forecasts of Technology Change

1995 Wireless and Cable Voice Services: Forecasts and Competitive Impacts

Depreciation Lives for Telecommunications Equipment

1996 Advanced Video Services: Analysis of Forecasts for Terrestrial Service Providers

APPENDIX B

Depreciation Lives for Telecommunications Equipment:

Review & Update

Local exchange carriers (LECs) have over $250 billion invested in their networks. Over 80% of this investment falls into three categories—outside plant, circuit, and switching. In each category, tremendous changes are underway which are obsoleting the bulk of existing investment and making necessary large amounts of new investment. Since telephone equipment has traditionally been assigned long depreciation lives, these changes mean that existing equipment will be obsolete, and likely out of service, well before existing investment has been recovered under current regulatory depreciation schedules. This report reviews our assessment of the situation and our recommendations for LEC depreciation lives.

Drivers for Change

There are three highly-interrelated drivers that are driving change in telecommunications: technology, competition, and new services. None of these are fully accounted for in the traditional approach to regulatory depreciation. This section briefly reviews these drivers and how they reinforce each other.

Technology Advance

Advances in technology are providing more efficient and functional ways of offering traditional telephone services, as well as wireless services, video services, and new digital communications. Four of the key technologies are:

- Fiber in the loop (FITL), including any architecture that extends fiber into the distribution portion of the local loop. The last link to the customer may be on fiber, copper pairs, coaxial cable, or wireless.

There are a number of architectures that are under consideration or are being planned. A true consensus has yet to emerge on a single FITL architecture. Continuing changes in technology costs, regulation, business relationships, market forecasts, and market share assumptions probably mean that consensus will be arrived at only gradually. Whatever architecture is chosen, it will displace the vast majority of copper investment.

- Advanced digital switching, especially Asynchronous Transfer Mode (ATM) switching.

The next major switching generation, ATM switching, is optimized to handle all types of traffic on the network efficiently and quickly. Today's digital switches use time division multiplexing to connect continuous streams of digitized voice or data at 64 Kb/s for the duration of a call. This is efficient for low-speed, circuit-switched applications such as voice, but it is unusable or inefficient for high-speed digital applications, especially those with bursty (non-continuous) traffic characteristics. ATM switches, on the other hand, use small fixed-length packets called cells. Unlike conventional packet switches, ATM switches do not introduce significant signal delay (because of the simple cell structure) which means they can be used for continuous, real-time applications such as voice and videoconferencing. However, since ATM uses packet switching, it is also good for bursty data traffic. The ability to handle all types of traffic, at all variable data rates, not only makes ATM an efficient switch, but it is also ideal for networked multimedia applications that use all types of communications.

- Synchronous Optical Network (SONET) transmission on fiber optic systems, including Next Generation Digital Loop Carrier (NGDLC) systems incorporating SONET.

SONET is a new format for organizing information on a fiber optics channel that recognizes the need for integrating different types of traffic on the same pair of fibers. Among its many advantages are standardized optical and electrical interfaces to which all suppliers must adhere. Another is that an individual information stream on a fiber channel can be efficiently separated from the rest of the information on the channel. With a SONET add-drop multiplexer, any signal can be extracted with a single piece of equipment without breaking down the whole signal. SONET add-drop multiplexers are already cost-competitive with asynchronous equipment, and soon will be commodity items that are integrated into almost every piece of circuit (and switching) equipment. This will render redundant much existing circuit equipment, including digital crossconnects and multiplexers.

Further, with SONET, carriers can mix-and-match circuit equipment so that they can use different manufacturers' equipment. This, of course, provides operational and equipment savings, as well as more competition between manufacturers. Later on, SONET interfaces will be built directly into switches, leading to even more equipment savings. NGDLC systems will directly link to switches through SONET interfaces. From the same unit, some channels may be connected to other switches or facilities using a built-in SONET add-drop multiplexer. Circuits could be transferred from one switch to another instantaneously. This will give carriers much more flexibility when it comes to dealing with switch manufacturers. SONET will benefit customers as well as carriers. In addition to the inherent economic benefits of a more efficient network, SONET will provide greater reliability through its support of fiber ring architectures and enhanced response time and flexibility in provisioning new channels.

- High-capacity digital wireless technologies such as Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA).

These digital wireless technologies can multiply the capacity of existing cellular systems by a factor of from three to 10 and will also be utilized with the new personal communications systems. One implication of the increased capacity is the ability to compete more directly with wireline service.

In a nutshell, the benefits of these technologies are reduced operating costs, reduced capital costs, better service, or, in some cases, new services. The technologies are all well-understood and do not require scientific, engineering, or economic breakthroughs to be deployed. There is widespread agreement about their benefits and cost targets. While there is some controversy about the details and timing, there is consensus that the future of telecommunications is built around these technologies.

Competition

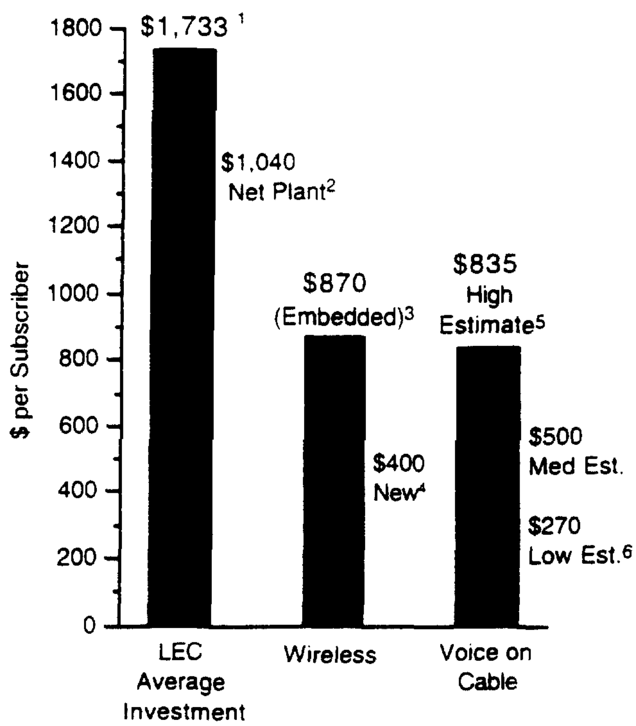
Competition has entered the local exchange business, and it will increase dramatically over the next few years. So far, most local exchange competition has centered on the large business customer. Competitive access providers (CAPs) are already serving large businesses in concentrated areas, and cable television companies are providing alternative access for high-bandwidth services. CAPs are installing the latest, most efficient technology—fiber optics, SONET, and, in cities/locations where they provide switched services, modern digital switching.

The next competitive arena will be the mass market for voice services. Such competition has already begun in public phones and, in some states, in intra-LATA long distance. Two additional, more pervasive sources of competition are cable television networks and wireless networks, specifically cellular and personal communications services (PCS). Technologies are emerging that will allow voice to be added to state-of-the-art cable systems at a cost that is less than on copper pairs. On a per-subscriber basis, cellular technologies are already less costly than wireline. With the new high-capacity digital wireless technologies, such as TDMA and especially CDMA, wireless technologies will also be less costly on a per-minute of use basis. Exhibit 1 illustrates some of these cost comparisons.

Because they are more efficient, the new technologies offer very substantial cost advantages to new entrants in local telecommunications. These new entrants can invest in the most efficient modern equipment without regard to an embedded infrastructure such as the LECs have. This, in turn, will pressure LECs to adopt new technology quickly in order to stay competitive. Thus, competition reinforces the technology drivers and magnifies the obsolescence of the old technology.

Exhibit 1

Investment Per Subscriber



Source: USTA Engineering Subcommittee on Depreciation

[1] Industry investment of $260 billion and 150 million access lines at year-end 1993.
[2] Net plant assumes 40% depreciation reserve (industry average at year-end 1993).
[3] Total wireless industry investment divided by number of customers (source: CTIA, year-end 1993).
[4] Annual wireless industry investment increase divided by customers gained (source: CTIA, year-end 1993).
[5] Estimate by Hatfield Associates, Inc. in a 1994 study for MCI. Alternative Distribution and Access Technologies. Includes land and buildings, switch, network interface unit, backhaul, and customer connection (similar to fee paid by cellular to sales agent, $320).
[6] Estimate by David P. Reed in "The Prospects for Competition in the Subscriber Loop: The Fiber-to-the-Neighborhood Approach," presented at the 21st Annual Telecommunications Research Policy Conference (September 1993). It represents costs allocated to telephony for upgrading a cable system for interactive TV and telephony

New Services

The third driver is the impending emergence of digital communications services for the mass market. These services will support both television and computer-based applications requiring digitized transmission of text, audio, and still and moving images. The applications for these services include advanced fax, computer-based imaging, LAN interconnection, videoconferencing, interactive multimedia, video on demand, and interactive television. Today, the market for digital communications services for these applications is relatively small; however, the potential for growth is tremendous, especially when these services are extended beyond large business customers.

Ultimately, the telephone network will provide full broadband, multimedia communications services based on three of the technologies we have mentioned: fiber optics, SONET transmission, and ATM switching. Along the way, intermediate steps will include narrowband Integrated Services Digital Network (ISDN) and video on demand services. Since some of the new services blur the traditional distinctions between telephony, television, publishing, information systems, and computing, they foster a new type of competition focused on the convergence of these industries. In this environment, competitive advantages belong to those companies that can deliver a package of diverse services for the least cost. As it happens, the new technologies allow delivery of multiple services at overall costs that are comparable or less than the traditional delivery mechanisms for the individual services.

Impacts on Depreciation Lives

Alone, any one of these drivers would cause significant change in the deployment of technology. Together, they are forcing unprecedented change that is rendering most of today's telephone network obsolete. Although satisfactory for voice services, today's network is expensive to operate and offers limited functionality in terms of mobility and digital services. It was optimized and constructed for the age of electromechanical and analog switching and copper cable, an age which for a decade has been giving way to digital switching and fiber optics. Much of the equipment placed in the last decade is becoming obsolete in the face of new technologies such as SONET and ATM. Thus, if LECs are to remain viable, they must rebuild their networks—sooner rather than later. This necessitates continued, massive investment in new technology that requires much shorter lives for existing investment than are currently prescribed by regulators.

Weaknesses in Regulatory Depreciation Methods

The traditional method for estimating depreciation lives is to examine mortality data for older vintages and assume that all vintages will experience the same age-dependent characteristics. For example, if 60% of the units of a particular technology installed in 1983 were still in service in 1989 (six years later), we would assume that 60% of the units installed in 1990 would still be in service in 1996 (again, six years later). (This greatly over-simplifies, but captures the basic idea.) The assumption of age-dependent retirements reflects a situation where wear-out or breakdown drives the replacement process. Under this model, new technology (or perhaps a new unit of old technology) replaces old technology only when the old technology wears out or breaks. This is an accurate model for some situations: for example, it reflects the way most companies replace motor vehicles.

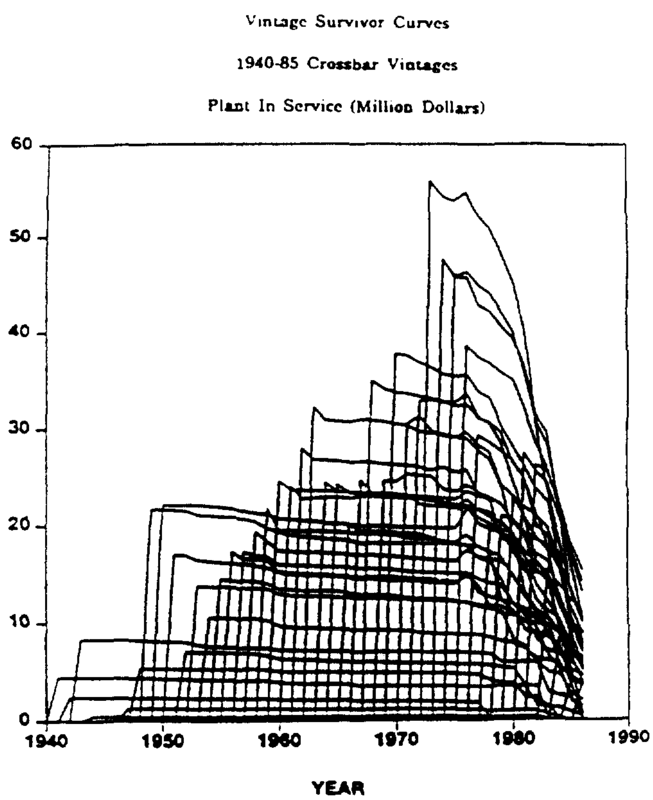
Today, however, technological obsolescence is a major cause of retirements in telecommunications for switching and circuit equipment, and is also expected to be for outside plant in the near future. (Other drivers—competition and new services—are largely reflected in this driver.) Mortality analysis alone is not appropriate in such a situation. This is made clear in Exhibit 2, which plots the vintage survivor curves for crossbar switching. These are similar to normal survivor curves except that a separate investment life cycle is shown for each vintage of equipment. Note the "avalanche effect" between 1975 and 1980. During this period, all vintages experienced sudden and simultaneous retirements, as electronic switching was rapidly adopted.

One can also see from the avalanche curves that, when technological obsolescence is the major driver for retirements, there is no such thing as a constant service life. Equipment purchased late in a technology generation will have a much shorter life than a piece of equipment purchased earlier. Further, the expected service life of equipment purchased late in the cycle is roughly the same as the average remaining life of existing equipment. These observations are contrary to mortality-based depreciation, but they reflect reality.

Most important, until the avalanche begins, life estimates for the old technology using mortality-based analysis will be based on an extension of the pre-avalanche trend and, thus, will be way too long. Not only will the life estimates be wrong, but they will be wrong right up to the moment the avalanche begins. To use a different metaphor, this is like paddling a rowboat without ever looking forward. You are over the falls before you know anything is wrong!

Exhibit 2

Avalanche Curves



Source: Bellcore

The original replacement technology for crossbar switching was analog stored program control (ASPC) switching, first introduced in the mid-to-late 1960s. Note that the avalanche of crossbar retirements begins in about 1975, more than five years after the introduction of the new technology.

Also note that very large amounts of investment were made in the old technology very late in its life cycle, even after the new technology was available. Although this behavior may seem odd, it is typical of many technologies and can often be perfectly rational. (For example, millions of 486 personal computers have been sold since the introduction of the replacement technology, the Pentium.) It can result from several factors:

(1) The need to maintain existing equipment and service levels.

(2) Restrictions on the availability of the new technology.

(3) High relative costs for the new technology early in its life cycle.

(4) An inherent bias toward the existing technology.

However, we must keep in mind that the last purchases of old technology will have especially short lives.

An important implication of this phenomenon is that recent investment patterns in the old technology tell us little about the likely adoption of new technology, even in the near future. Purchase volumes of the new technology may be smaller than those of the old technology almost to the time the avalanche begins.

Using Technology Forecasting to Estimate Depreciation Lives

Fortunately, there are reliable methods that allow us to forecast future technology changes and, thus, depreciation lives. Developed and tested over many years in telecommunications and other industries, these methods have proven to be very reliable for forecasting. Their basis lies in an understanding of the process of technology change and the use of available data to produce quantitative forecasts.

One technology forecasting method, substitution analysis, has been proven effective in projecting the adoption of new technologies and the obsolescence of old technologies. Substitution refers to the displacement of an established technology by a newer technology when the new technology provides substantially improved capabilities, performance, or economies. With substitution, technological superiority of the new technology—not wear-out—is the driver for replacement.

With substitution analysis, we examine patterns of technology substitution. The pattern is remarkably consistent from one substitution to another, and is characterized by an S-shaped curve when the market share of the new technology is plotted over time. Exhibit 3 shows the S-shaped curve for the Fisher-Pry model. Of the several substitution models available, in general, we have found the Fisher-Pry model—and its extensions, notably, multiple substitution models based on the same principles—to be the most useful for forecasting. The adoption of a new technology starts slowly because, when it is first introduced, a new technology is usually expensive, unfamiliar, and imperfect. The old technology, on the other hand, has economies of scale and is well-known and mature. As the new technology improves, it finds more and more applications, it achieves economies of scale and other economic efficiencies, and it becomes generally recognized as superior. The old technology, because of its inherent limitations and falling market share, cannot keep up. The result is a period of rapid adoption of the new technology, beginning at the 10% to 20% penetration level. This corresponds with a period of rapid abandonment of the old technology, i.e., the avalanche. Toward the end of the substitution, adoption of the new technology slows down again as the last strongholds of the old technology are penetrated.

Since the pattern of how a new technology replaces an old one is consistent, we can apply the pattern to a technology substitution in progress, or one just beginning, to forecast the remainder of the substitution and estimate the end date for the old technology. We can apply substitution analysis even in cases where the substitution has yet to begin by using appropriate analogies, precursor trends, or evaluation of the driving forces. More information on the Fisher-Pry model and its application is provided in Attachment 1.

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